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(PROFESSIONAL PAPER.)

AMERICAN PLUM BORER.[1]

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CONTENTS.

	Page.		Page.
Introduction	1	Emergence of spring brood of moths	6
History	2	Oviposition of first generation of moths	7
Distribution	2	Length of life of moths of spring brood	9
Food plants	3	Habits of the moths	9
Feeding habits and character of injury	3	Incubation of first-brood eggs	10
Description of stages	3	First-brood larvæ	10
The egg	3	Hibernation	11
The larva	4	Natural enemies	12
The pupa	4	Remedial measures	12
The adult	4	Bibliography	13
Spring pupation of wintering larvæ	5		

INTRODUCTION.

In the summer of 1912, while engaged in deciduous fruit insect investigations at Winchester, Va., the writer's attention was attracted by the common occurrence upon apple of the American plum borer, *Euzophera semifuneralis* Walk. Although injury to fruit trees by the larvæ of this insect was recorded by Forbes in Illinois as early as 1890, very little has since been published concerning it. This lack of attention may be attributed to the fact that though common and widely distributed it has never occurred in sufficient numbers or been sufficiently destructive to call upon it any special notice as an economic species.

The food habits of this insect are particularly interesting when contrasted with those of other wood-boring species. It is also an insect that under certain conditions is capable of doing considerable damage to trees which have been injured either mechanically or by the attacks of fungous diseases. At the suggestion and under the direction of Mr. A. L. Quaintance, of the Bureau of Entomology, an attempt was made, therefore, in the summer of 1913 and 1914, to study the insect's biology.

For the photographs presented in this paper the writer is indebted to Mr. Fred E. Brooks, of the Bureau of Entomology.

[1] *Euzophera semifuneralis* Walk.; order Lepidoptera, family Pyralidæ.

HISTORY.

This species was first described by Walker, in 1863, under the name of *Nephopteryx semifuneralis*. In 1881 Zeller redescribed and figured it as *Euzophera impletella*. In 1887 Hulst described the species as *Stenoptycha pallulella*. In 1889 we find the first published reference to the immature stages of this insect; S. A. Forbes, in his report for that year, described the larvæ as injuring Chinese plum (*Prunus simoni*) in Illinois. Forbes gave it the common name of American plum borer. In 1891 D. S. Kellicott reported it as injuring mountain ash in Ohio, and in 1898 Otto Lugger included it in a list of "Butterflies and Moths Injurious to our Fruit Producing Plants." In 1901 E. D. Sanderson reported it as injuring apple and Kieffer pear in Delaware, giving a few notes on its probable life history in that locality and renaming it the "fruit-tree bark borer." Slingerland and Crosby have given a short account of this borer in their recent "Manual of Fruit Insects."

While Forbes's report is the first published reference to the feeding habits of the larvæ of this insect, we find in the unpublished notes of the Bureau of Entomology, February 2, 1879, the following note: "Received from E. A. Schwarz, Jackson, Miss., one cocoon found under bark on fence around cotton field. The moth issued and proves to be either *M. distinctella*, or one that comes very near to it." This specimen was later determined by H. G. Dyar to be *Euzophera semifuneralis* Walk. Again, May 14, 1879, in the notes of the Bureau of Entomology, Theo. Pergande records finding a cocoon on peach and rearing a moth belonging to the Pyralidæ, which he names rather doubtfully *Acrobasis* sp. A later determination by Dyar proved this also to be *Euzophera semifuneralis*.

DISTRIBUTION.

Dyar gives the distribution of this borer as "United States." Zeller described the species in 1881 from four specimens from Colombia, South America, one of which was taken at Mariquita on August 10 and the other at Honda the last of April. Hulst notes that his description was based on specimens from New York, Utah, and Washington. In the United States, specimens in the collection of the United States National Museum, and the correspondence, notes, and collection of the Bureau of Entomology, as well as the literature available, indicate that the insect occurs in the following States: Arkansas, Arizona, Colorado, Delaware, Florida, Georgia, Illinois, Indiana, Kansas, Missouri, Maryland, Mississippi, North Carolina, New York, Ohio, South Carolina, Texas, Utah, Virginia, West Virginia, Washington, and the District of Columbia.

FOOD PLANTS.

This insect does not, by any means, confine its attacks to plum. It has been taken feeding upon plum, peach, cherry, Chinese plum (*Prunus simoni*), Kieffer pear, mountain ash, persimmon, apple, and Russian mulberry. The writer has found it equally abundant on plum, cherry, peach, and apple. It will probably attack the trees of any of the common stone or pome fruits when the proper conditions are presented.

FEEDING HABITS AND CHARACTER OF INJURY.

As has already been stated, the food habits of this insect are of especial interest when contrasted with those of other wood-boring species. The plum borer prefers trees which are not dead and yet are not in a too vigorous condition. The attention of the writer was first attracted to the work of this borer by an apple tree upon which it had established itself. This tree had been partially girdled by a disease commonly known as collar blight. Under the skirt of bark bordering the wounded area the borer had begun its work and by extending its galleries out into the living tissue had completed the girdling of the tree. This seems to be the characteristic form of injury for the species. Beginning at some scar, wound, or crevice, where a bark scale offers partial protection, the larva works its way back into the living tissue, in broad, shallow, irregular galleries just beneath the bark. Apple trees partially girdled by collar blight and trees injured mechanically by frost or by some other factor offer the ideal condition for the work of this borer. Without injury of some sort to its host plant the borer rarely succeeds in establishing itself, and entirely healthy and uninjured trees are in little danger from its attacks. On the other hand, where a tree has suffered injury the work of this borer may, in many cases, considerably shorten its life. Pl. I, *a*, *b*, *c*, shows the character of the galleries and the condition of trees most liable to attack.

DESCRIPTION OF STAGES.

THE EGG.

When first deposited the egg appears as a regular oval, opaque white body, coarsely punctate. The size is fairly uniform, the average for 10 being 0.59 mm. by 0.42 mm. A marked change takes place in the appearance of the egg as incubation proceeds. Twenty-four hours after deposition the color changes from white to a pinkish tint, or in cases where incubation is somewhat delayed to a light brown, and in 48 hours to a dull red. In three to four days a slight depression appears in the center and 24 hours before hatching the color

changes to a dirty white with the head of the larva plainly visible at one end. The unfertilized egg remains white. After hatching the shell is white and retains its shape. The eggs are deposited singly or in small irregular groups, usually in cracks or crevices of the bark, or in the absence of such places they are rather insecurely glued to smooth surfaces (Pl. II, *e*). They are easily broken away from the surface to which they are attached.

THE LARVA.

In leaving the egg the larva (Pl. II, *b*) gnaws out an irregular hole in one end and leaves the shell in two or three minutes. The newly-hatched larva is very active; its color is white throughout with the exception of the very large dark brown head, and the alimentary tract which shows plainly from its reddish coloration. After a few days of feeding the color of the body changes to a dingy white and later to a brownish green, somewhat lighter on the ventral surface. The full-grown larva averages about 25 mm. in length by 3 mm. in width. The head is dark brown; the cervical shield, pale yellow, with black markings on either side. The anal plate is brown and the thoracic legs are light brown with darker tips. There is great variation in the color and size of individual specimens.

THE PUPA.

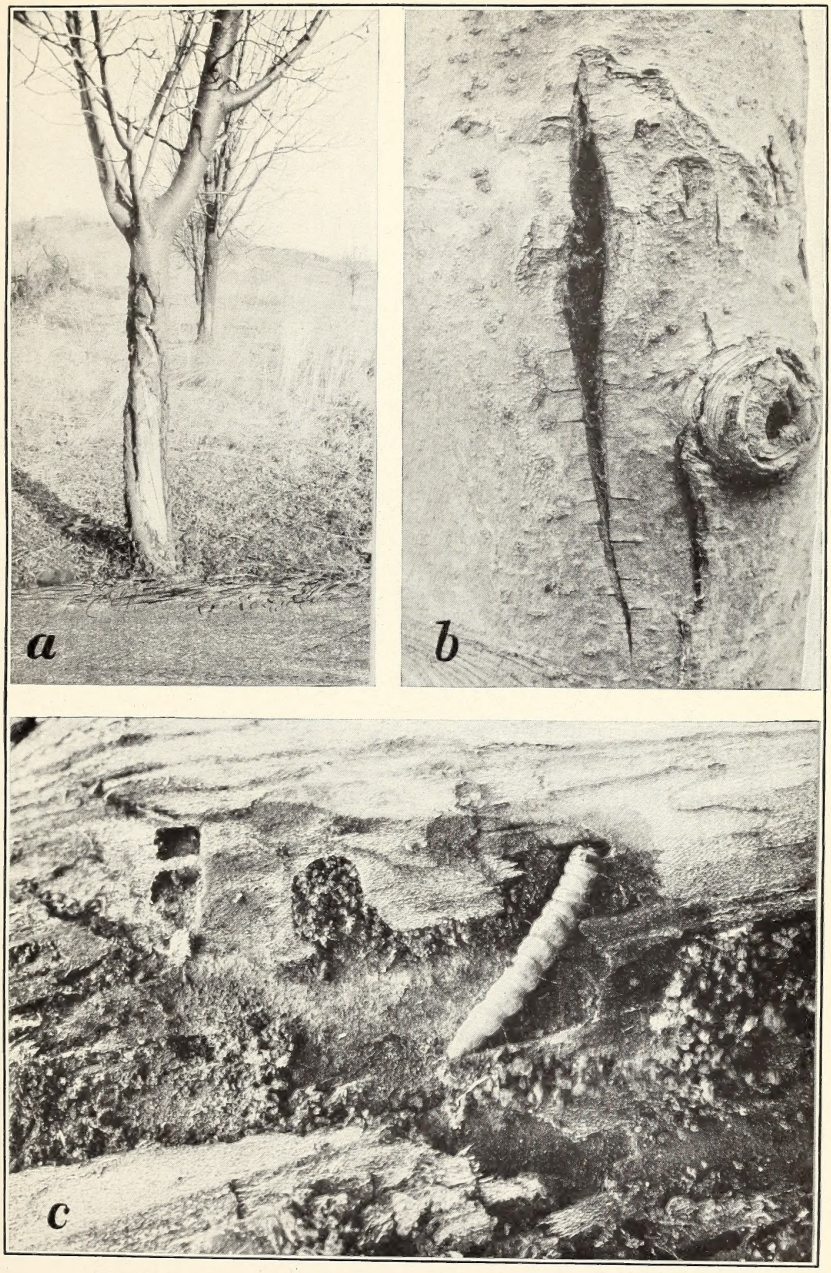
When first formed, the color of the pupa (Pl. II, *f*) is light olive green, which changes in one or two days to light brown and 24 hours before emergence to dark brown and then black. The size is variable, but averages about 10 mm. by 3 mm. The wing sheaths are somewhat lighter brown and extend about two-thirds of the total length of the body. The eyes are black, the spiracles well defined, and the last abdominal segment has a variable number of stout hooked spines.

THE ADULT.

The adult female (Pl. II, *a*) measures about 1 inch across the expanded wings. The average measurements of 10 specimens were: Spread of wings, 19.5 mm.; length of body, 8.4 mm.; width of body, 1.4 mm. The head, thorax, legs, and abdomen are a light gray. The fore wings are grayish brown with a broad, wavy band of black and brown markings across the outer third. There is considerable variation in the color pattern of the fore wings, however, and frequently these markings are almost or entirely absent. The hind wings are smoky with a distinct black marginal line.

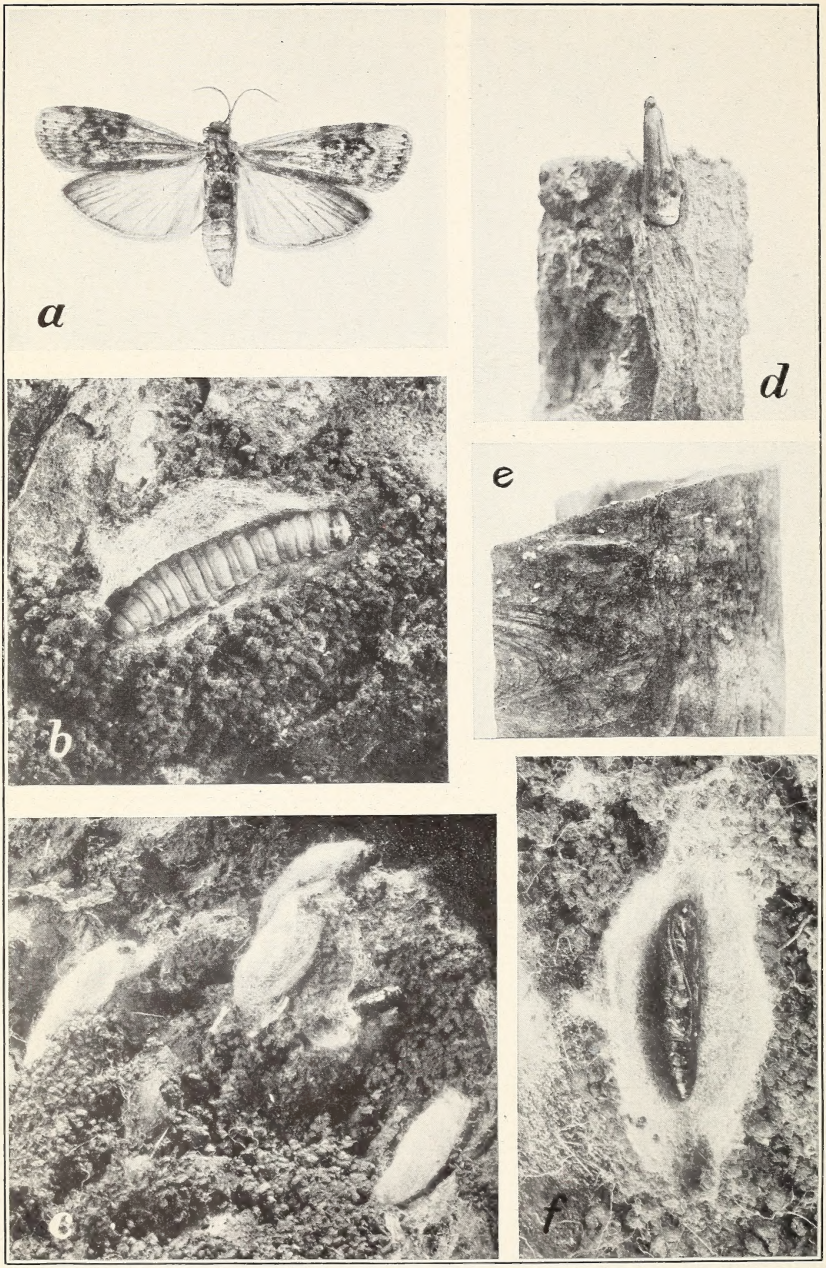
The insect was first described by Walker in 1863. The following is his description:

Nephopteryx semifuneralis n. s. *Female*, blackish cinereous, dingy cinereous beneath. Palpi smooth, slender, hardly curved, obliquely ascending, not rising higher than the



WORK OF THE AMERICAN PLUM BORER (EUZOPHERA SEMIFUNERALIS).

a, Plum orchard in which the trunks of the trees are being injured by the plum borer; *b*, crack in bark of apple tree through which larvæ of the plum borer entered; *c*, galleries and young larva of the plum borer. (Original.)



THE AMERICAN PLUM BORER.

a, Adult, about twice natural size; *b*, winter cocoon opened to show larva, enlarged about one-half; *c*, mass of winter cocoons embedded in frass and silk under scale of cherry bark; *d*, characteristic resting posture of adult; *e*, eggs, about natural size; *f*, cocoon opened to expose pupa, about twice natural size. (Original.)

vertex; third joint lanceolate, nearly as long as the second. Abdomen extending beyond the hind wings; hind borders of the segments pale cinereous; wings moderately broad; fringe long, cinereous. Fore wings hardly acute; middle and exterior lines cinereous, undulating, blackish-bordered; discal mark cinereous, curved; marginal points black; exterior border convex, hardly oblique. Hind wings dark cinereous, very slightly hyaline; marginal line brown. Length of the body 5 lines; of the wings 12 lines.

a. North America. From Mr. Carter's collection.

SPRING PUPATION OF WINTERING LARVÆ.

At Winchester, Va., in the spring of 1913, pupation of the wintering larvæ began about the last of March to the first of April. Frequent collections of larvæ were made previous to and including March 24, and pupation had evidently not begun up to that time. Absence from Winchester prevented further observation for a period of 14 days following March 24, and during this interval, of the 31 larvæ that had been taken in the field previous to that date, 18 had pupated by April 7. However, the temperatures from April 4 to April 7 were so extremely low that insect life generally was almost dormant and most of this pupation must have occurred before the former date.

Girault in 1906 records the pupation of three larvæ under his observation in the insectary at Washington, D. C., as occurring on March 27, 28, and 31, respectively. At Myrtle, Ga., in the same year, both Rosenfeld and Girault observed pupation as early as March 2, or about 25 days earlier than in the latitude of Washington. Girault, in 1905, took four pupæ in the field at Myrtle, Ga., March 1. In the latitude of northern Virginia and the District of Columbia, in a normal season, pupation evidently begins about April 1 or possibly a little before, depending upon the relative lateness of the season, and as far south as Georgia probably a month earlier.

The 23 individual records of the pupal stage included in Table I were taken from field-collected material kept in an out-of-doors rearing shelter. In most cases the larvæ under observation were kept in their winter cocoons (Pl. II, *c*), which are so loosely woven that the transformation of the insect within can be easily seen. Occasionally it was necessary to force the larvæ to spin up in glass vials, but this was avoided as far as possible, as the insect under such conditions probably does not feel the full effect of the changes in outside temperature.

TABLE I.—*Length of pupal period of wintering larvæ of the plum borer, Winchester, Va., 1913.*

No. of observation.	Date of—		Length of pupal period.
	Pupation.	Emergence.	
			Days.
1	Apr. 14	May 17	33
2	14	15	31
3	17	15	28
4	19	16	27
5	19	21	32
6	22	21	29
7	24	18	24
8	24	21	27
9	24	21	27
10	24	21	27
11	25	24	29
12	25	27	32
13	25	27	32
14	26	27	31
15	26	27	31
16	May 2	27	25
17	2	27	25
18	4	June 2	29
19	4	May 30	26
20	5	June 2	28
21	6	2	27
22	6	2	27
23	7	3	27
Maximum			33
Minimum			24
Average			28.43

The longest pupal period observed was 33 days, the shortest 24, and the average of the 23 observations 28.43 days. The records at Winchester show a slightly longer duration of this stage of the insect's life than has been observed by others, though data from other sources are rather limited. Girault, in 1905, notes that one larva pupated in the insectary at Washington March 28 and emerged April 21, a period of 24 days, while Rosenfeld, at Myrtle, Ga., in 1906, reports one insect that transformed from larva to adult in 20 days. Fred Johnson, at Youngstown, N. Y., in 1905, has the following note: "Larvæ confined in jar form cocoons June 28. Adults emerged from these July 20 and others continued to appear until August 4." Evidently some of the insects in this instance transformed in less than 23 days. The weather conditions of the spring of 1913 may be partially the cause of the longer pupal period at Winchester, the unusually high temperature prevailing through March hastening the insect's pupation, while the relatively cold April that followed probably delayed the emergence of moths.

EMERGENCE OF SPRING BROOD OF MOTHS.

Table II gives in detail the time of appearance of 79 moths that emerged at Winchester in the spring of 1913 from field-collected rearing material. The first adult appeared in the laboratory on April 25 and by the fore part of May the insect was emerging in numbers.

TABLE II.—*Emergence of spring brood of moths of the plum borer at Winchester, Va., in 1913. (See fig. 1.)*

Date of observation.	Number of moths emerging.	Date of observation.	Number of moths emerging.
Apr. 25	1	May 19	3
29	6	23	5
May 3	10	27	1
7	34	31	2
11	6	June 4	8
15	3	8	6
		Total..	79

Girault, in 1905, records one adult that emerged at Washington as early as April 21 and later notes that empty pupal cases were very plentiful in the field by May 2. In normal seasons adults probably begin appearing in the latitude of Winchester and Washington from the last of April to the first of May. Rosenfeld, in 1906, observed emergence in Georgia as early as March 29, or about one month earlier than it occurred at Washington the preceding year. In 1913 maximum emergence occurred at Winchester on May 7, twelve days after the first moth appeared, and adults continued to emerge in the rearing cages in lessening numbers until June 4. The seasonal appearance of the moths can be more easily appreciated by reference to figure 1.

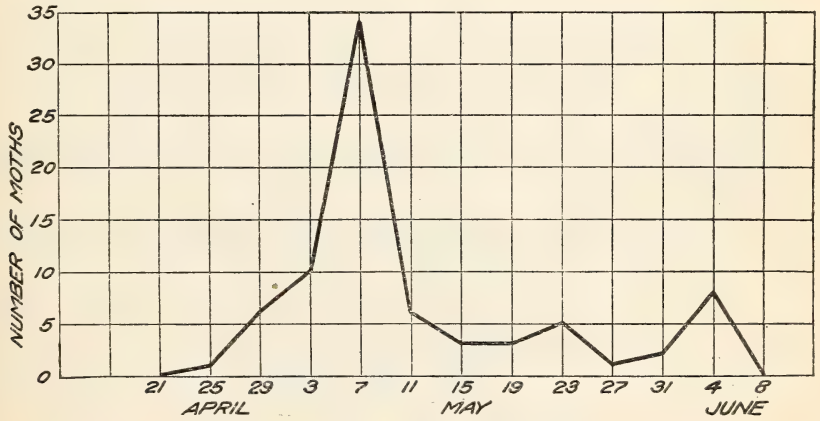


FIG. 1.—Diagram showing emergence of spring brood of moths of the American plum borer (*Euzophera semifuneralis*) at Winchester, Va., in 1913. (Original.)

OVIPOSITION OF FIRST GENERATION OF MOTHS.

As the moths emerged from day to day they were transferred to jars containing twigs of plum or apple wood, all of those issuing on the same date being confined in one jar and a record kept of the number of eggs subsequently deposited. Eggs were laid freely on the twigs, singly or in small groups in the cracks and crevices of the

bark, or very often were rather insecurely glued to the sides and bottom of the jar as well.

From Table III it will be seen that the moths began to oviposit in from 1 to 3 days after emergence, the average for seven observations being 1.7 days. On the average, oviposition lasted 2.3 days, the longest period observed being 4 days and the shortest 1 day. Girault records three moths that oviposited in confinement in the insectary at Washington, May 8, 1905, the duration of oviposition being 2 days.

TABLE III.—*Oviposition of the spring brood of moths of the plum borer, Winchester, Va., 1913.*

No. of cage.	Number of moths.	Date of—			Days—		
		Emergence.	First oviposition.	Last oviposition.	Before oviposition.	Of oviposition.	From emergence to last oviposition.
1	6	Apr. 26	Apr. 29	May 2	3	4	7
2	5	May 2	May 3	6	1	4	5
3	3	3	6	6	3	1	4
4	8	4	5	6	1	2	3
5	5	5	7	7	2	1	3
6	2	5	6	7	1	2	3
7	6	6	7	8	1	2	3
Maximum					3	4	7
Minimum					1	1	3
Average					1.7	2.3	4

Copulation was never observed, but evidently occurred very soon, since in several instances fertile eggs were deposited within 24 hours of emergence. In the absence of the male the female deposits infertile eggs freely.

The number of eggs deposited in confinement per female is indicated in Table IV.

TABLE IV.—*Number of eggs of the plum borer deposited per female in confinement, Winchester, Va., 1913.*

Date.	No. of females under observation.	Number of eggs.	
		Deposited.	Deposited per female.
April 26	1	45	45
May 2	2	50	25
3	2	24	12
5	1	74	74
Average			32.2
Maximum			74
Minimum			12

Records were kept of the number of eggs laid, in two jars containing 2 females each and in two jars containing 1 female each. The

condition of the moths in confinement is of course quite unnatural. The greatest number of eggs laid by one female was 74. In one instance only 24 eggs were deposited in a cage containing 2 females and the minimum is stated as 12, although it is of course possible that only one female was ovipositing.

Girault, May 8, 1905, gives a record of three adults, emerging in the insectary at Washington, that deposited 78 eggs, an average of 26 eggs each. No observations were made in the field that would throw any light on this part of the insect's life cycle.

LENGTH OF LIFE OF MOTHS OF SPRING BROOD.

The length of life of 17 adults is given in Table V.

TABLE V.—*Length of life of moths of the spring brood of the plum borer, Winchester, Va., 1913.*

No. of moths.	Length of life.	No. of moths.	Length of life.
	Days.		*Days.*
1	3	2	11
1	4	1	12
2	6	2	13
1	7	2	15
1	8	1	18
1	9	1	23
1	10	.....	.....
Total		17	139
Maximum			23
Minimum			3
Average			8.2

These moths were supplied with sweetened water. Several cages of moths were given nothing in the way of food or water and several were given water alone. The observations were too limited to justify the drawing of any conclusions as to the influence on longevity of sugar and water compared with water alone, but those given neither, as a rule, lived only a few days after oviposition.

The moths fed upon sweetened water lived from 3 to 23 days, the average of 17 observations being 8.2 days. No data were obtained upon the relative longevity of the sexes.

HABITS OF THE MOTHS.

When resting the moth assumes the characteristic position seen in Plate II, figure *d*, the wings tightly folded, the legs pulled in closely and set far back under the abdomen. The rigid posture of the body and the blending of the ashy grays and dark browns of the fore-wings produce to the human eye at least a close resemblance to a short twig. During the day the moths remain in this posture for hours at a time, and until the eye has become accustomed to this

adaptation of the insect they are easily overlooked in the rearing cages.

As a rule the moths are rather inactive during the day, though egg laying is by no means entirely limited to the hours of darkness. The moths are evidently active at night. Forbes (1890) records taking them at night in Illinois.

INCUBATION OF FIRST-BROOD EGGS.

Table VI shows the incubation period of first-brood eggs.

TABLE VI.—*Incubation period of first-brood eggs of the plum borer, Winchester, Va., 1913.*

Number of eggs observed.	Date—		Period of incubation.
	Deposited.	Hatching.	
			Days.
36	Apr. 29	May 7	8
3	May 2	10	8
8	3	11	8
11	4	12	8
32	6	19	13
38	7	21	14
19	8	21	13
Average			10.3

The shortest incubation period observed was 8 days, the longest 14, and the average for seven lots of eggs was 10.3 days. The long incubation required by the three lots of eggs deposited on May 6, 7, and 8, respectively, is entirely due to the cold wave of May 8, 1913. The temperatures were so extremely low that incubation very probably ceased altogether. The 8-day period required by the first four lots of eggs probably represents more nearly the average incubation period under seasonable temperature conditions. As a rule the incubation period for the individual eggs of a given lot varied only a few hours, and in recording observations for any lot of eggs incubation was considered over when the first egg hatched.

FIRST-BROOD LARVÆ.

An attempt was made to rear larvæ at Winchester on plum wood. A number of old plum trees were transplanted in May to the vicinity of the laboratory. As the larvæ hatched they were transferred to these trees. All began feeding at once. Unfortunately predaceous enemies and parasites destroyed all but one of these larvæ before they reached maturity. This larva hatched on May 7, from the first lot of eggs obtained in the laboratory, spun up on June 10, pupated June 12, and emerged June 22. The feeding period in this case was 34 days; the prepupal period, 2 days; the pupal period, 10 days.

Two pupæ taken in the field on July 14, which from their light olive-green color had just transformed, emerged on July 22, indi-

cating a pupal period in this case of 8 days. Another mature larva taken in the field pupated in the laboratory on July 18 and emerged July 30, giving a pupal period of 12 days. Two moths emerging in the laboratory on July 22 deposited eggs the following day.

A second generation, or, at least, a partial one, occurs in the latitude of Winchester. As just stated, one adult emerged on June 22, from a larva which hatched in the laboratory on May 7. The indicated life cycle for the first generation is as follows: Incubation, 10 days; feeding period, 34 days; prepupal period, 2 days; pupal period, 10 days; from emergence to egg laying, 1 day; entire length of life cycle of first generation, 57.3 days.

Apparently eggs of the first generation begin hatching in the fore part of May and of the second generation about July 1. Whether all of the first-brood larvæ transform to moths the same season is not apparent from the information at hand. It seems fairly certain, however, that there is at least a partial second generation. There is evidently considerable overlapping of the two generations. Adults are emerging more or less throughout the summer and it is possible to find at almost any time larvæ of all sizes. Pergande, in 1898, records rearing one moth in the insectary at Washington from a larva sent to him from Anderson, S. C., as late as October 24, and the writer has observed newly hatched larvæ at Winchester September 28.

HIBERNATION.

In the late fall the larva constructs, under the bark scales at the entrance to its feeding galleries, a loose, light, but very tough cocoon of white silk. To the outside of this are often fastened frass and small pieces of bark. Numerous observations in the seasons of 1912 and 1913 indicate that many of the larvæ go into the winter in an immature state, yet in the spring of 1913 no evidences of feeding were found among about 100 larvæ collected in the field. All of the undersized specimens, of which there were a considerable number, proved to be parasitized. In 1912 newly hatched larvæ were found in the field as late as September 28, and in favorable years immature larvæ may succeed in passing the winter successfully in northern Virginia. In the writer's opinion, however, the mortality due to winter killing among the immature larvæ must be very high in this latitude.

When disturbed or exposed to the light the larva leaves its winter cocoon and spins up in a more protected place. However, as a rule, unless disturbed or unless the winter cocoon is located in an unsatisfactory place, the larva pupates in the same cocoon in which it passes the winter. Larvæ have never been observed passing the winter as "free larvæ," even parasitized specimens spinning a cocoon. In fact, even during the summer months the insect usually threads a light shelter at the end of its burrow where it rests when not feeding.

NATURAL ENEMIES.

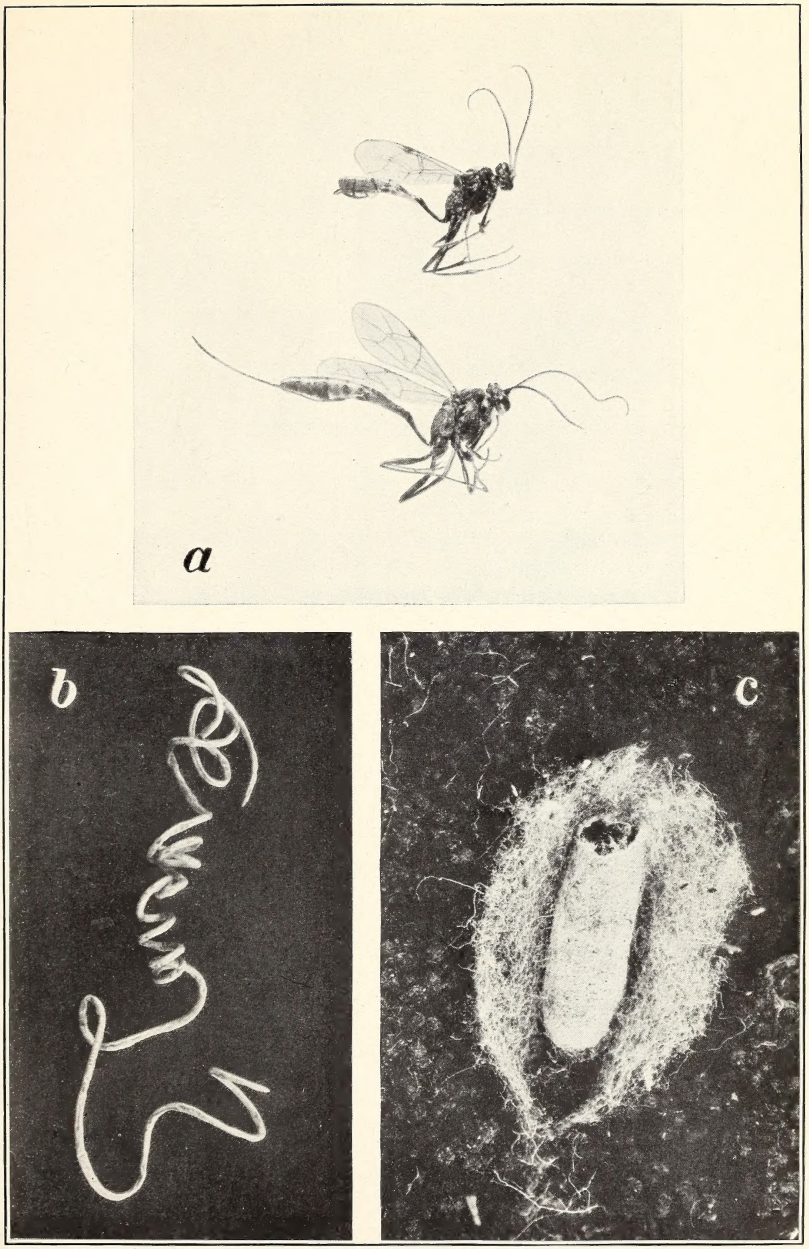
The larvæ of *Euzophera semifuneralis* are attacked by a number of parasitic and predaceous enemies. Two parasitic forms were reared at Winchester in 1913, which were determined by Mr. R. A. Cushman, of the Bureau of Entomology, to be *Idechthis* sp. (Pl. III, *a*) (Quaintance No. 10402) and *Mesostenus thoracicus* (Cress.). The former was by far the more common. Of 104 overwintering larvæ collected in the field 14 were parasitized by this insect. This proportion of parasitized specimens, amounting to 13.47 per cent, indicates that the parasite may aid very materially in the control of the borer. The parasitized larvæ are about one-half normal size and usually lack the greenish-brown color of healthy specimens. At some time during the prepupal period the parasite matures, devours the larva, and spins its cocoon (Pl. III, *c*). Fred Johnson, in 1905, at Youngstown, N. Y., reared an undetermined member of the family Ichneumonidæ (Quaintance No. 574). J. H. Beattie, in 1905, at Fort Valley, Ga., reared from borer larvæ *Itoplectis marginatus* (Prov.), *Mesostenus gracilis* Cress., and *Pimpla* sp. (Quaintance No. 399).

Mr. Fred E. Brooks, of the Bureau of Entomology, records rearing a hairworm, probably a species of Mermis (Pl. III, *b*), from larvæ of the plum borer.

Among the predaceous enemies the larva of *Tenebroides corticalis* Melsh. has been taken feeding upon the borer. Ants and woodpeckers are also important factors in reducing the numbers of this insect.

REMEDIAL MEASURES.

As has already been stated, the plum borer will probably never become a pest of more than ordinary importance, except in occasional isolated cases. Its food habits are such that it is entirely unable to establish itself upon vigorous, healthy, uninjured trees. However, in common with a number of other insects it does deserve some attention on account of its ability to do considerable real injury where the proper conditions are presented, i. e., where trees have been injured by hail, frost, or attacks of fungous diseases, and its rather indiscriminate choice of food plants increases its opportunities in this direction. One of the most common instances of this in the observation of the writer is in the case of the collar blight of apple, where the injury done by this disease is frequently supplemented by subsequent attacks of the plum borer. When the ordinary precaution of cutting away the dead bark and painting the wounded areas is followed, this may be regarded as sufficient for the control of the borer. Where the borer has established itself already the cutting-out method is the only one that can be followed. Nothing may be expected from the application of poisonous washes.



PARASITES OF THE AMERICAN PLUM BORER.

a, *Idecthis* sp., a common parasite of the plum borer; upper figure, male; lower figure, female; considerably enlarged; *b*, hairworm reared from larva of the plum borer in 1912 at French Creek, W. Va., much enlarged; *c*, cocoon of the parasite *Idecthis* sp. within the cocoon of its host, much enlarged. (Original.)

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